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13. ABSTRACT (Maximum 200 words)

Equipment was purchased to carry out experiments to characterize the dynamic response and failure of polymer composites under dynamic compressive loads. A high speed framing camera with variable frames, instrumentation amplifiers for load cells, strain gage signals, and high-speed data acquisition were purchases. Details are given in the report. The total budget with cost sharing was $370,000.

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Instrumentation for the Dynamic Response and Failure of Polymer Matrix Composites

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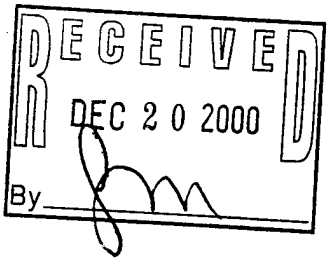

Final Report submitted on

Dec. 11, 2000

Army Research Office Scientific Officer : Dr. M. Zikry

This document constitutes the final report on work carried out under ARO Grant 39319-EG-RIP for the purchase of instrumentation that is necessary to carry out experimentation for the purpose of understanding and uncovering the dynamic response and failure of polymer matrix composite materials under dynamic compressive loading. Specifically, we purchased a high speed framing camera with variable framing rates and digital capability, instrumentation amplifiers for amplifying load cell and strain gage signals for the purpose of recording, a modern high speed data acquisition system for acquiring the data signals at high rates(5 Msa/s) and also with the capability of performing large scale operations on digital images, and a tetrahedron press for the in-house manufacture of the composite samples. In addition, accessories that are needed to supplement the efficient use of these pieces of equipment were also purchased. Table 1, shows the purchased items and the costs associated with the purchases.

The research that the instrumentation will facilitate has three phases. In phase I, test coupons (polymer based fibrous laminated composites) that have a circular cylindrical shape and also flat plaque type coupons are manufactured in-house. These samples contain fibers of different mechanical properties in the same polymer matrix material. The ability to manufacture specimens of this type lends itself immediately to examining the effect of fiber properties on the dynamic compressive response of such materials. In addition, the effect of fiber volume fraction on the dynamic compressive response is also equally important and is being currently studied. The tetrahedron press allows the possibility of curing test samples under controlled pressure and temperature. Several, currently popular matrix materials require a controlled temperature/pressure cycle for proper processing. Such a capability is present in the Tetrahedron press. This capability was used in manufacturing the samples. Furthermore, because of the high temperature (600 degrees Celcius) curing capability, this press allows us to examine and experiment with materials that have a very high glass transition temperature. Experiments with such materials is planned for the near future. In phase two, the specimens are loaded dynamically using the SHPB and the NSWC, thereby characterizing the strain rate dependency and the mechanism of failure and how the mechanisms are influenced by constituent properties and microstructural detail. In this manner, information about the constituents are obtained in a consistent manner, which enables the development of associated mechanics models for assessing dynamic compressive strength.

The experimental work that that the instruments facilitate is currently underway. For the research component of this work, the PI has received funding from the ARO under a separate grant (Compressive Failure of . Several papers and presentations stemming from this research have been made and/or are slated for future publication. These are given below:

1) S.H. Lee and A. Waas, "Compressive Failure of Unidirectional Composites", *Int. J. of Fracture*, vol. 100, pp275-306, 1999.

2) S. Lee, Chandra S. Yerramalli and Waas, A. M. "Compressive Splitting Response of Glass Fiber Reinforced Unidirectional Composites", accepted to appear, *J. Composites Science and Technology*, 2000

3) Chandra S. Yerramalli and Waas, A. M. "Compressive Splitting Response of Glass Fiber Reinforced Unidirectional Composites using a Shear Lag Approach", in review, *Int. J. Fracture*, 2000

4) Chandra S. Yerramalli and A. Waas, "In-situ static matrix properties obtained from torsional response of glass fiber and carbon fiber polyester composites ", in review, *ASME J. Engineering Materials and Technology*, 2000.

5) Chandra S. Yerramalli and A. Waas, "In-situ dynamic matrix properties obtained from dynamic torsional response of glass fiber and carbon fiber polyester composites", in preparation, to be submitted to *ASME J. Engineering Materials and Technology*, 1999.

6) Y. Chandrasekar and A. Waas, Torsional and Combined Load Response of Glass Fiber and Carbon Fiber Vinyl Ester Composites, Soc. Engineering Science Meeting, Univ. of Texas at Austin, Sept. 1999.

7) Chandra S. Yerramalli and Waas, A. M. "Compressive Splitting Response of Glass Fiber Reinforced Unidirectional Composites using a Shear Lag Approach", to be presented at AIAA SDM Meeting, April 2001.

The above publications serve the purpose of disseminating the research work that the purchased equipment facilitate. In addition to the above publications, several other ongoing research programs have also benefited from the purchased instrumentation. Thus, the purchased equipment serves the purpose it was intended for as well as supplement additional research work conducted by the PI and his associates. Table 1 shows the purchased equipment.

Table 1

UM Cost sharing Funds: $44,000.00

US-DOD –ARO Funds: $325,600.00

Total Cost of Purchases: $369, 147.05

Total Budget: $370,000.00

Item No.	Item description	Price
1	Data Acquisition System, with image processing capability. Dual Pentium II Xeon Class	$31,960
2	Vishay Signal Amplifiers and Conditioners with Signal Processing Software	$20,804
3	Kodak 4.2.1 Mega Plus CCD Camera	$37,995
4	National Instruments Data Acquisition Cards	$6,316
5	4 channels of high speed data acquisition	$3,215
6	Variable Framing Rate Cordin Digital Camera	$220,000
7	HP Infimum Oscilloscope	$11,397
8	Questar Imaging Lens	$4,494
9	Tetrahedron Press	$20,274
10	Portable Field Image Data Acquisition System	$5,792
11	Small Oven for Curing	$4,315
12	50 GB Hard Drive for Data Storage and other accessories	$2,585.05